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ABSTRACT

The University of Wisconsin College of Engineering's Sociotechnical Systems Design (STSD) Program, which was developed to provide social science students with systems concepts and basic technological skills necessary for attacking these problems, is considered. The need for such professionals, current educational responses, the organization of the program, and problems encountered in implementing an interdisciplinary program that integrates engineering and social science concepts are addressed. In addition to integrating technical and social science thinking, the program is designed to develop persons with an integrated systems, esthetic, and values structure; to disseminate technology and systems knowledge, skills, and insights; to prepare social science students for continuing life growth; and to produce STSD capability within organizations. The program was developed by engineering and social science faculty and consists of four three-credit courses. Two core courses, systems techniques and sociotechnical design concepts, form the basis for student work. Students also take a third course on some aspect of engineering of particular interest and a fourth course, an STSD integrative seminar. The program can be implemented at the advanced undergraduate or graduate levels. The need for such professionals is indicated by a national yearly exponential increase in demand for persons trained in the understanding of broad social and human issues plus specific technical knowledge. The demand is arising from health and health care planning agencies, educational systems, government agencies, and private and public social welfare systems. (SW)

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DEPARTMENT OF INDUSTRIAL ENGINEERING

SOCIOTECHNICAL SYSTEMS DESIGN: AN ENGINEERING PROGRAM FOR SOCIAL-SCIENCE STUDENTS

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SOCIOTECHNICAL SYSTEMS DESIGN: AN ENGINEERING PROGRAM FOR SOCIAL-SCIENCE STUDENTS

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There is currently a lack of broadly educated personnel capable of solving problems which concern the integration of social considerations and modern technology. The University of Wisconsin College of Engineering has developed the Sociotechnical Systems Design (STSD) Program to provide social-science students with systems concepts and basic technological skills necessary for attacking these problems. This paper discusses the need for such professionals, current educational responses, the organization of the UW STSD Program and problems encountered in implementing an interdisciplinary program which integrates engineering and social-science concepts.

Background

As industrial and social systems internally grow more complex, they exert increasing influence and force greater accountability upon each other. One discipline may not pose specific solutions for problems of, say, industry, without considering data generated by disciplines studying social, economic, physical, or financial ramifications.

General societal responses to these problems appear to fall in the following categories:
(1) Placing technologists, scientists, engineers, etc., in charge of programs related to sociotechnical problems. Some of these efforts are obviously successful. However, practical experience shows that real-world projects handled only by engineers tend to have somewhat disastrous effects. Ida Hoos[1] and Garry Brewer[2] document the difficulties of technologists when placed in charge of projects.
(2) Placing social scientists in charge of programs related to sociotechnical problems. In this view, the social scientist is to be the "decision-maker" and the administrator or person in charge. Yet, it is becoming apparent that this isn't working as well as it should. Engineering and technology will continue to be significant resources for solving the problems of the world; thus, the social-science-trained individual needs to have this kind of background to adequately take charge of the problem.
(3) Establishing interdisciplinary teams for work on projects. This approach at least helps avoid past tendencies to apply any technology that promised benefits even though there might be damaging side effects. Because the social sciences usually talk about problems and engineering usually solves problems, they are put together in this kind of effort. The hope here is that team members with different viewpoints will "rub off" a bit of each other's background. In many cases this works, but in most, it does not simply because preparation for either side has been inadequate.

The social scientist is trained to have a "divergent view" within an often narrowly disciplinary framework. He looks into "discipline-relevant" aspects of a problem and deliberately searches out its multiple facets. The engineering view, "convergence," seeks to bring things together to find a specific answer and not to develop generalizations and theories. The effect, the best hope for future interdisciplinary teams, will rest on explicit training in the other form of thinking for each field.

Educational responses to the problem have generally been of three types:
(1) Bringing the social sciences into engineering education. These programs seek to "knock the rough edges off" of the engineer. Some schools have received grants from the Alfred P. Sloan Foundation to "assist them in carrying out activities in creative design in engineering education." Yet Walter Lynn[3] notes that courses in social and human concerns are merely "add-ons" in an engineering curriculum and the knowledge is not integrated into the engineering professional and design activities.
(2) Preparing engineering courses for nonengineers. Engineering colleges have generally recognized the problems discussed thus far. They have actively created courses that nonengineers could take to learn something about technology and the methods engineers use. Yet, the courses are not really organized to provide any degree of cohesiveness for the social-science student. They are "add-ons" for them, too. The courses are also isolated and do not represent a cohesive program.
(3) Setting up courses/programs on the interface between society and engineering/technology/science. As valuable as these are, they tend to focus on raising the problems of interactions and unintended consequences rather than on how an individual or group can do anything about them. They are "consciousness raising" and

make people aware of the interplay, with the assumption that, once one knows about the problems, he will be able to do something about them. This relatively naive assumption is generally found wanting, usually failing to provide sufficient insights about either side to let the participants move toward developing effective solutions.

A national yearly exponential increase in demand is arising from health planning agencies, educational systems, government agencies, health care delivery systems, private and public social welfare agencies, and similar groups for persons trained in the understanding of broad social and human issues plus specific technical knowledge. Engineers generally recognize that for the next ten to twenty years social-science-trained individuals will occupy decision-making positions. In addition, the same people will rise to higher decision-making levels in many technologically-related areas. In order to be effective as well as truly liberally educated, they should be able to understand engineering and technology as well as possess problem-solving and systems design engineering skills. We would call such a person a sociotechnical systems designer.

Sociotechnical Systems Design Program[4]

Purposes

The STSD Program at the University of Wisconsin-Madison seeks to prepare such professionals. The program adds technical expertise within systems and design concepts to existent social-science foundations (senior or graduate student status) to result in thoroughly trained sociotechnical systems designers. We don't presume to replace alternate ways, but rather to add this logical and "needed" direction. This emphasis should produce individuals who seek solutions as well as research generalizations, people who use convergent techniques as opposed to divergent approaches.

Thus, the benefits of Sociotechnical Systems Design training appear to be great:

(a) STSD training will enable a person with a social-science background to tackle problems by applying a convergent view;

(b) STSD training will give a person with a social-science background a "true" liberal education because of his introduction to the technological aspects of society;

(c) STSD training will let a person with a social-science background know when, how, and where to get engineering, technology and/or science experts involved in real-life problems;

(d) STSD training will enable a person with a social-science background engineering and systems tools for use in social-science research.

(e) STSD training will give a person with a social-science background engineering and systems tools for use in social-science research.

We can paraphrase our principle purpose here as: the Sociotechnical Systems Design Program shall concern the art of integrating technical and social-science thinking. We further feel this program has several higher level purposes: to provide to society persons with an integrated systems, esthetic, and values structure; to disseminate technology and systems knowledge, skills and insights; to prepare social-science students for continuing life growth incorporating technology and systems design knowledge, skills, and insights; and to produce STSD capability within organizations.

Organization

The STSD Program was developed by engineering and social-science faculty and consists of four three-credit courses. Two core courses, Systems Techniques and Sociotechnical Design Concepts, form the basis for student work. These two courses emphasize general engineering system and design concepts which are presented in ways which are consistent with the limited mathematics and science backgrounds of most social-science students. Figures 1 and 2 list the topics covered in these two courses.

Systems Techniques Topics

1. Systems Perspective
2. Models and Modeling
3. Structural Modeling
4. Discrete Modeling
5. Large-Scale and Ill-Defined Systems
6. Modeling for Computer Simulation
7. Examples of the Use of Systems Techniques
8. Technology Assessment (TA)
9. Mini-Project Work

Figure 1

Sociotechnical Systems Design Topics

1. Planning & Design (P&D) Perspective
2. Axiomatic Foundations
3. P&D Propositions
4. Issues about P&D
5. Decision-Making
6. P&D Strategy
7. Involvement of People
8. Continuing Change and Improvement Programs
9. Role of Organized Knowledge
10. Examples of P&D
11. Reports on Projects

Figure 2

In addition to these courses, STSD students take a third course on some aspect of engineering of particular interest. This course is chosen so that each student's STSD program can be directly related to the student's concerns. Several courses for non-engineers are available from various College of Engineering departments. However, for students whose STSD program objectives would be best met by a general course on

engineering and technology rather than a course focussed on a particular engineering discipline, the STSD staff is developing a course on The Technological Community. This course focuses on the technological basis of any modern community and covers such topics as transportation, energy generation and distribution, waste disposal, water supply, and communication. The course emphasizes the integrated nature of these various sociotechnological systems from a general systems approach perspective.

For a final course, each student takes an STSD Integrative Seminar. This course focuses on integrating the knowledge gained in the other three courses by having students apply their knowledge to the solution of current problems of particular interest to them. Student projects are chosen so as to utilize both STSD knowledge and the students' primary social-science concerns.

The twelve credit STSD package is designed to be implemented flexibly in various degrees of depth according to the needs of each student. Thus, the STSD program can form the basis for a Masters degree in Sociotechnical Systems Design, or as a senior area of emphasis for advanced undergraduates, or, with more indepth study, as a PhD minor. Two students recently received special STSD Masters degrees and one anthropology student is using the program as the basis for a PhD minor.

Implementation and Dissemination

The STSD program has completed the first stages of development. The two core courses were pilot tested during the 1976-77 school year and will be offered again during fall semester 1977. Student evaluations of these courses indicate that students feel that the concepts presented will be useful in terms of both their current studies and future careers. The Technological Community and STSD Integrative Seminar courses will be pilot tested spring semester 1978.

One objective of the STSD program is to disseminate materials and information about the UW STSD program to other interested Colleges of Engineering. To begin this effort, letters were sent to 200 deans of Colleges of Engineering around the country explaining the STSD program concept and asking if they would be interested in obtaining program materials for implementation in their own universities. Over half of the Deans expressed interest in the program and requested that they be sent materials as they were developed rather than waiting for the final report. As a result of these requests, an STSD "Newsletter" was established to keep deans informed about program progress and results.

Potential Problem Areas

Two requirements for having an STSD-type program are to offer appropriate courses and to have social-science students take them. In setting up such a program, there are potential problem areas associated with these requirements.

First of all, the courses developed for the program must be appropriate for the purpose intended, viz, the education of social-science students. This means that the choice of course content must be compatible with a social-science perspective rather than being based on a conventional engineering viewpoint. Illustrative examples should be developed which go beyond the strictly engineering aspects to include broader societal concerns. Although engineering has its terminology, many words are shared by engineers and social scientists. Unfortunately, the meaning for many of these words is different. In order to have an appropriate course, one must be sensitive to possible differences in the meaning of various terms; it is possible to converse for many hours only to discover that there has been no communication because of the different meanings associated with certain words. The best check for course appropriateness is to discuss the proposed course in detail with social-science faculty members.

In terms of being able to offer courses, new courses require faculty and administrative approvals of one sort or another. The approval process tends to raise other issues. Engineering faculty members have been known to question things such as the desirability of offering courses for non-engineers (e.g., because of the dilution of engineering effort), the basis for the funding of the program, and whether or not it is proper to give engineering credit for coursework that is not strictly engineering in nature. Even administrative matters, such as the computer kicking out a course and a clerk forgetting to code a course for liberal arts students, can greatly affect the implementation of a program. Thought needs to be given to issues such as these.

In obtaining enrollment, social-science students must be free to participate in the program and to receive course credit applicable to degree requirements. Here the issues involve the social-science faculty, some of whom may question whether engineers can contribute anything of relevance to their students and many of whom may resist the idea of their students going outside the appropriate disciplinary framework. As such, the initiation of a successful program requires careful and extensive consultation with key members of the social-science faculty. A period of "shakedown" is to be expected, in which the social-science faculty who are interested may have to be brought to see the distinction between an STSD program and a more theoretical "Science, Technology and Values" program. During this period, personal relations and the differences between "convergent" and "divergent" thinking will lead to a sorting out of potential "core" members of the STSD program team.

The matter of problem solving itself is a central concern of the Design Concepts course. Most social-science students are introduced to a great deal of theory in their disciplines. Problem solving in these contexts often means researching published materials, comparing and

contrasting authorities, and producing abstract, generalizing solutions. Application of theory to specific and immediate problems is not widely emphasized in undergraduate training. Thus, students from such disciplines often know a great deal about a subject, but lack grounding in how to use their concepts and select those which are useful to a specific problem solution. For both engineers and social scientists, the Design Concepts course as well as the whole STSD framework can produce sometimes surprising areas of misunderstanding.

Closure

An STSD-type program is worth setting up in a College of Engineering. It addresses current societal needs in preparing social-science students to cope with the technological world. It also prepares them actually to utilize some of the systems and design ideas that engineers have developed. It may well be the appropriate packaging of the oft-repeated engineering claim that engineering ideas ought to be part of a "liberal" education.

Interesting spin-offs can be expected due to such STSD collaboration. For example, an existing course in Technology and Change will be team taught by an engineering professor and an anthropology professor for the first time in 1977-78.

A successful STSD-type program requires collaboration with the social-science faculty right from the start. For example, the engineering faculty must work with the social-science faculty in developing the program, rather than taking a program to them for comments. Implementation of a program is best considered at the inception of the actual planning.

Footnotes

1 Hoos, I., Systems Analysis in Public Policy: A Critique, Berkeley: University of California Press, 1972.

2 Brewer, G., Politicians, Bureaucrats, and the Consultant: A Critique of Urban Problem Solving, New York: Basic Books, 1973.

3 Lynn, W., "Engineering and Society Programs in Engineering Education," Science, Vol. 195, January 1977.

4 STSD Program is partially funded for 1975-78 by grant number HES75-17159 of the National Science Foundation.

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Gerald Nadler is a Professor of Industrial Engineering at the University of Wisconsin, Madison. He served as Chairman 1964-67 and 1971-75. He is a registered professional engineer in Missouri and Wisconsin. Dr. Nadler is active in research and has produced contributions in several areas: the patented UNOPAR to measure the velocity of any body member, health systems design and research, planning large scale complex systems, and design methodologies. His current interdisciplinary research and applications include developing methodologies for and installing improvement programs in hospitals, individually guided education in secondary schools, and programs in engineering and technology for social science students.